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SEDIMENT DEPOSIT IN CARBURETORS

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SEDIMENT DEPOSIT IN CARBURETORS.

GENERAL.

The difficulties encountered with the jelly-like precipitate found in carburetors are not new ones, as can be shown by previous correspondence and reports. A letter on the subject of carburetor sedimentation and the means of preventing same, dated November 16, 1918, was translated from the French, the introduction reading as follows:

"A considerable amount of trouble was experienced by the engine division with American Zenith carburetors, by reason of a deposit which was apparently caused by corrosion of the aluminum. In several cases it was said to have been the cause of crashes, and we were requested to recommend a remedy for this trouble."

A memorandum was received in regard to this same white deposit found in carburetors, requesting that a more sensitive test be devised for determining the acidity of fuels. This was written on the strength of assertions of previous investigators that the deposit was due to either sulphuric or sulphonic acids, either not removed or else formed in the refining.

Samples of this corrosion have been submitted from various aviation fields at different times. Not only that found in carburetors but also in the aluminum gasoline tanks. One carburetor brought to our attention contained considerable jellylike masses, sufficient to prevent its functioning.

PURPOSE.

To determine the chemical content of a sediment often encountered in carburetors, to determine the cause of its formation, and to find a means of overcoming the difficulty.

CONCLUSIONS.

The bulk of all the deposits analyzed consisted of the oxide of aluminum in the various stages of hydration, from aluminum hydroxide to practically anhydrous oxide of aluminum. Most of the samples of corrosion were contaminated with organic matter, a small amount of sulphates, chlorides, carbonates, and the oxides of iron.

The aviation gasoline in use at the Engineering Division, Air Service, McCook Field, will not in itself cause the corrosion of aluminum alloys used in carburetor manufacture. The cause of this corrosion is attributed to the presence of water, which probably condenses in small droplets and, due to its higher gravity, finds its way to the bottom of the containers below the gasoline level. The gasoline above prevents the evaporation, so that there is a gradual accumulation. Twenty-four hours' contact of this water with the aluminum alloy castings employed caused considerable corrosion. In one week's time a large amount deposited.

Of the corrosion preventive applications investigated, the special gasoline-proof baking black enamels gave very

satisfactory results. The coatings should be applied by means of an air brush, as this method of application fills the surface pores more satisfactorily. This enamel must pass the following test:

GASOLINE-WATER TEST.

One coat shall be applied by means of an air brush to a cast cup $2\frac{1}{2}$ inches inside diameter, 3 inches deep, of $\frac{1}{4}$ inch wall thickness, made of aluminum alloy, the same as used in carburetor manufacture. Place 100 c. c. of gasoline and 25 c. c. distilled water in the cup and allow it to stand for 100 days. At the end of this period there should be no visible sediment, precipitate, or signs of corrosion in the cup. The solution shall be clear and the coating unaffected.

MATERIAL.

For exposing the various coatings to the action of gasoline and water, the standard porosity cups, $2\frac{1}{2}$ inches inside diameter, 3 inches deep, and $\frac{1}{4}$ inch wall thickness, were used. The 10 per cent copper, 90 per cent aluminum alloy, which is used in the manufacture of carburetor bowls was used "as cast" in the tests. The water glass used was the ordinary commercial variety, diluted in accordance with Specification No. 20002. Several air-drying black enamels, spar varnish, special gasoline-proof dope, shellacs, and baking enamels were investigated as to their exposure properties against gasoline and water.

METHOD OF PROCEDURE.

Quantitative chemical analysis was performed on all samples of carburetor and aluminum gasoline-tank sediments submitted by various aviation fields and by the different sections of the Engineering Division. These analyses consist in the determination of the loss in weight of the deposit upon heating to 100° C. and also upon ignition. The metallic elements and acid radicals were next determined.

Porosity cups of 10 per cent copper and 90 per cent aluminum were made in the foundry for the purpose of testing different corrosion inhibitors. Two cups were given identical treatments for every application under investigation. One set of cups was tested untreated for comparison with the coated cups; and to compare the nature of the deposit formed with that acquired in service. One of the two cups of each set was tested against gasoline alone, while the other was tested with both water and gasoline. The following list gives in detail the coating and the method of application and exposure:

Nos. 1 and 2. No coating. Exposed April 10, 1922.

Nos. 3 and 4. Treated with water glass according to specification. Exposed April 10, 1922.

Nos. 5 and 6. Treated with water glass, baked three-quarters of an hour at 350° F., washed with hot water, and dried. Exposed April 10, 1922.

Nos. 7 and 8. Same as Nos. 3 and 4, except that they were washed out with hot water after drying in the air. Exposed April 10, 1922.

Nos. 9 and 10. Sample No. 715, air-drying black enamel from Lowe Bros. Applied with air gun. Exposed April 10, 1922.

Nos. 11 and 12. Sample No. 387, baked, black enamel, Lowe Bros., for three hours at 350° F., thinned with 10 per cent turpentine and applied with air gun. Exposed April 10, 1922.

Nos. 13 and 14. Sample No. 1210, baked, black enamel, Kay & Ess Co., for three hours at 350° F., thinned with 10 per cent turpentine and applied with air gun. Exposed April 10, 1922.

Nos. 15 and 16. Sample No. V-306, Valspar, Valentine Co., thinned with 50 per cent turpentine, air drying, dipped. Exposed April 10, 1922.

Nos. 17 and 18. Sample No. 83383, red Engenamel, Du Pont, thinned with 50 per cent Du Pont thinner, air drying, dipped. Exposed May 4, 1922.

Nos. 19 and 20. Sample MS/672, bright black enamel, Du Pont dope, thinned with Du Pont thinner 50 per cent, No. 85882, dipped. Exposed May 12, 1922.

Nos. 21 and 22. Sample No. 1072, Noco, Non-Corrosive Paint Co., not thinned, dipped. Exposed May 13, 1922.

Nos. 23 and 24. Wade lacquer, not thinned, dipped. Exposed May 19, 1922.

Note: 25 c. c. distilled water added to all even numbers.

RESULTS.

The deposits submitted ranged from jellylike masses to hard crystalline granules, the analysis of which showed them to be of approximately the same constitution, excepting as to the water content. Each of the samples upon exposure to atmosphere lost a part of the water content and eventually took on the crystalline form. Analysis of the jellylike substance showed it to be principally aluminum hydroxide, which upon exposure to atmosphere became dehydrated to the form of oxide of aluminum.

A sample of dried sediment taken from an aluminum gasoline tank showed the following approximate analysis:

	Per cent.
Hydrated alum oxide.....	82
Aluminum sulphate.....	3½
Chlorides.....	5
Carbonates.....	5
Iron.....	2
Organic matter.....	2½

Another dried sample submitted by Lieutenant Ward from another flying field, taken from the bowl of a carburetor, showed a very similar analysis. A carburetor brought to our attention contained considerable jellylike masses, sufficient to prevent the functioning of the carburetor. An analysis of this material while still in the moist condition give the following results:

	Per cent.
Water.....	78
Alumina.....	15½
Organic matter.....	5½
Iron, sulphates, chlorides, etc.....	1

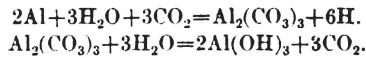
In the above analysis it is seen that 78 per cent of the formation found is water. In fact, water was found in all sediment submitted. The tests of the jelly proved conclusively that the compound was aluminum hydroxide. Distilled water in contact with this alloy of aluminum gave a deposit which showed a similar analysis and which visually had the same constitution, with the exception that the organic matter was absent.

Table 1 constitutes the outline of the results obtained when the various applications were exposed to the action of gasoline alone and to gasoline and water.

DISCUSSION OF RESULTS.

The conclusions drawn as to the nature of the deposit found in carburetors are substantiated by analysis on five samples of deposit sent in for examination from various localities, which no doubt use fuel from different sources. Although the analysis of the samples showed the presence of sulphates, chlorides, iron, copper, etc., these impurities formed only a very small proportion of the whole, so that the chief concern lay in the hydroxide of aluminum. Previously, without thorough investigation, the deposit has been reported as principally sulphates, carbonates, etc., but upon closer study no doubt exists as to the real composition of the precipitate. Its appearance alone, while in the moist condition, eliminates the conclusion that it is composed of sulphates, chlorides, or carbonates of aluminum.

When the alloy is immersed in gasoline alone, no sign of corrosion is evidenced. If a little distilled water is added, however, a similar flocculent precipitate forms in a very short time. Even in the absence of gasoline, a deposit of the same composition as that found in carburetor bowls forms. It is thought that the action of carbon dioxide dissolved in the distilled water is responsible for the attack on the aluminum. The assumption is that the weak carbonic acid dissolves the aluminum, with the formation of aluminum carbonate, which, because of its instability, breaks down to aluminum hydroxide and carbon dioxide according to the following equations:



It will be seen that the carbon dioxide which furnishes the reaction in the first equation is again liberated in the second, so that it is not consumed but is present for further attack on the aluminum. The fact that a precipitate is formed and that the cause of corrosion is regenerated, there should be no stop in the formation of the precipitate. Exposure tests bore this out.

Referring to the report of the determination of water in gasoline, it is evident that water must get into the tank and settle to the bottom, since not enough water can

originally be dissolved to cause this amount of corrosion. It is thought that the air in the tank at the low temperature of the higher altitudes reaches the dew point, which causes the accumulation on the tank sides and eventually runs to the bottom. After it once gets to the bottom with the blanket of gasoline covering it, it can not evaporate again. In time, therefore, considerable could collect and reach the bowl of the carburetor.

In the table of results obtained on exposure by the use of various treatments and applications, it will be seen that all failed, except those which were baked. The baked water-glass treatment and the two black baking enamels

gave satisfactory results when exposed for 100 days to water and gasoline. The remainder of the treatments either would not resist the action of gasoline or water, or both. Some became gummy in contact with gasoline, others too brittle to withstand vibrations, and a few changed color below the water level, which showed that they had deteriorated.

On the strength of the results of this investigation, it is recommended that a specification baking enamel be applied by means of an air brush to all aluminum bowl carburetors. The specification for this enamel is being formulated at the present time.

TABLE No. 1.

Cup No.	Exposed to—	Treatment.	Exposure.		
			7 days.	80 days.	100 days. ¹
1	Gasoline.....	None.....	O. K.	O. K.	O. K.
2	Gasoline and water.....	None.....	Slight jelly-like precipitate.....	Large amount precipitate.....	Failed.
3	Gasoline.....	Water glass, air-dried.....	O. K.	O. K.	O. K.
4	Gasoline and water.....	....do.....	O. K.	Solution hazy.....	Failed.
5	Gasoline.....	Water glass, baked, and washed.....	O. K.	O. K.	O. K.
6	Gasoline and water.....	....do.....	O. K.	O. K.	O. K.
7	Gasoline.....	Water glass, air-dried, washed.....	O. K.	O. K.	O. K.
8	Gasoline and water.....	....do.....	O. K.	Large amount precipitate.....	Failed.
9	Gasoline.....	Black enamel, air-dried.....	O. K.	Coating gummy.....	Failed.
10	Gasoline and water.....	....do.....	O. K.	....do.....	Failed.
11	Gasoline.....	Black enamel, baked.....	O. K.	O. K.	O. K.
12	Gasoline and water.....	....do.....	O. K.	O. K.	O. K.
13	Gasoline.....	....do.....	O. K.	O. K.	O. K.
14	Gasoline and water.....	....do.....	O. K.	O. K.	O. K.
15	Gasoline.....	Spar varnish.....	O. K.	O. K.	O. K.
16	Gasoline and water.....	....do.....	O. K.	Solution hazy.....	Failed.
17	Gasoline.....	Dope.....	O. K.	O. K.	Failed.
18	Gasoline and water.....	....do.....	O. K.	Solution hazy.....	Failed.
19	Gasoline.....	Special gasoline-proof dope.....	O. K.	O. K.	O. K.
20	Gasoline and water.....	....do.....	O. K.	Coating attacked by water.....	Failed.
21	Gasoline.....	Shellac.....	O. K.	O. K.	O. K.
22	Gasoline and water.....	....do.....	O. K.	Coating attacked by water.....	Failed.
23	Gasoline.....	....do.....	O. K.	Coating brittle.....	Failed.
24	Gasoline and water.....	....do.....	O. K.	Coating attacked by water.....	Failed.

¹ "Failed" in this column means either that a precipitate formed, that the solution became hazy, or that the water caused a color change in the coating, or that the coating became gummy or brittle.

